The Surveillance of Work-Related Pesticide Illness: An Application of the Sentinel Event Notification System for Occupational Risks (SENSOR)

Neil Maizlish, PhD, Linda Rudolph, MD, and Kathleen Dervin, MPH

ABSTRACT

Objectives. In response to limitations in state-based occupational disease surveillance, the California Department of Health Services developed a model for surveillance of acute, work-related pesticide illness. The objectives were to enhance case reporting and link case reports to preventive interventions.

Methods. Elements from surveillance of communicable diseases and sentinel health events were used to integrate a model into the preexisting system in one agricultural county.

Results. Between 1988 and 1991, 45 Fresno County health care providers reported 230 suspected cases, of which 217 from 80 work sites met reporting guidelines. Risk factors were profiled from interviews of 81 prioritized case patients and 36 employers. Fifteen work sites were visited and 117 recommendations were made, of which 6% were identified in enforcement inspections. Pest management experts consulted with growers on reducing future pesticide use.

Conclusions. Risk factors for pesticide illness were prevalent. Agricultural inspectors did not detect routine and serious hazards. Integrated pest management should be expanded and linked to occupational health. Agricultural enforcement personnel should be oriented and trained in occupational safety and health. (*Am J Public Health.* 1995;85:806–811)

Introduction

Occupational health surveillance at both the state level and the national level has been characterized as "fragmented" and "70 years behind" that of communicable disease.[1] As one response, the National Institute for Occupational Safety and Health proposed a model for state agencies—the Sentinel Event Notification System for Occupational Risks (SENSOR)[2]—that combines traditional communicable disease reporting by individual health care providers[3] with selected occupational sentinel health events.[4] Case reports of work-related conditions such as pesticide poisoning would be screened, analyzed, and prioritized by a central agency that would also coordinate follow-up at the work sites of "index" cases.

Since 1973, California has required physicians to report all pesticide illness cases to local health officers by telephone within 24 hours of treating patients (Pesticide Illness Reports); for occupational cases, they must mail a written form within 5 days to the state labor department (Doctors' First Reports). All agricultural pesticide illness reports are then investigated, usually by county agriculture departments that enforce among the strictest and most comprehensive pesticide regulations in the United States.[5] Nonetheless, there are persistent concerns that occupational pesticide illness is seriously underreported[6] and that little progress has been made to reduce the endemic annual incidence below 1000 cases.[7,8]

Within the existing reporting system, the California Department of Health Services developed a targeted and active surveillance model designed to (1) enhance the quantity and quality of case reporting, (2) identify risk factors and high-risk work sites, and (3) link preventive interventions to specific work sites and the general community. This article describes cases, work-site-specific risks and recommendations, and temporal changes in case reporting.

Materials and Methods

The generic SENSOR model[3] was adapted[9] for surveillance of acute work-related pesticide illness in Fresno County, California. This county has an agricultural work force of more than 60 000 on 7000 farms, and these farms produce over 250 crops worth an estimated $2 billion annually.[10] Introductory and regular meetings were held with diverse sectors of the Fresno community to describe the goals of the project and to obtain feedback. These sectors included the county health department, the county agricultural commissioner's office, the state department of food and agriculture, the Occupational Safety and Health Administration, labor organizations and farmworker legal advocates, agribusiness groups, pest control professional associations, and medical societies.

Case Reports

A survey of 491 county physicians, in specialties likely to treat occupational

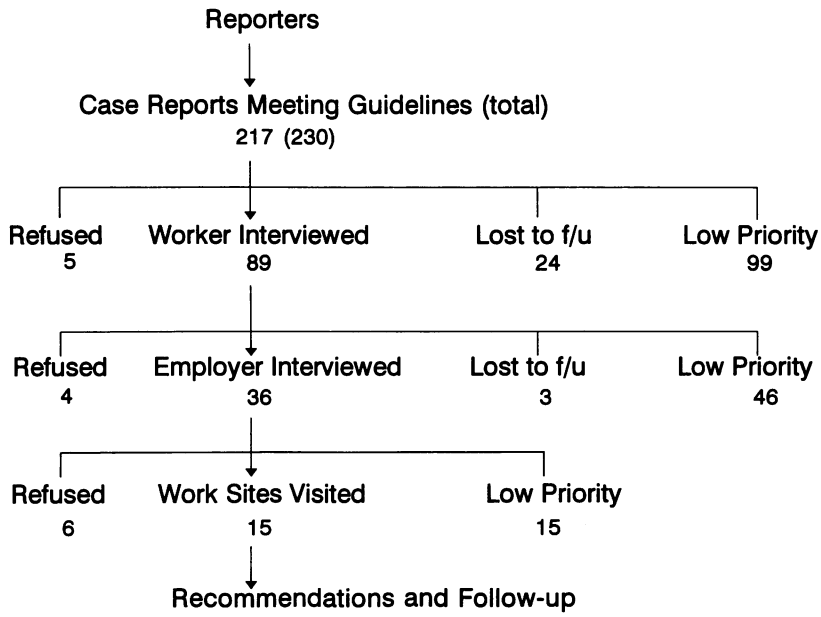
At the time of this study, the authors were with the California Department of Health Services, Berkeley. They are now with the California Department of Industrial Relations, San Francisco.

Requests for reprints should be sent to Neil Maizlish, PhD, 1226 Carlotta Ave, Berkeley, CA 94707.

This paper was accepted November 23, 1994.

Note. The views expressed here are the authors' and not necessarily those of the organizations acknowledged.

Editor's Note. See related editorial by Ordin and Fine (p 762) in this issue.



Note. In median days, reports were received 1 day after treatment, worker interviews were completed 5 days later, employer interviews were completed 7 days after worker interviews, and field investigations were completed 19 days after employer interviews. Written reports were available 66 days after the site visit. Low-priority cases consisted largely of cases involving unlikely or uncertain case confirmation status, those of mild severity, or those occurring at nonagricultural work sites. Case patients were considered lost to follow-up after five attempts by telephone or in-person contact.

FIGURE 1—Protocol for pesticide illness case follow-up, California SENSOR.

TABLE 1—Demographic and Occupational Characteristics of 190 Patients with Work-Related Pesticide Illness Reported by California SENSOR Providers, 1988 through 1991

	No.	%
Men	139	75
Spanish surname	137	73
Spanish language spoken at home	65	49
Industry (Standard Industrial Classification codes)		
Agriculture (01–09)	91	47
Grape farm	16	8
Aerial spraying/dusting	15	8
Deciduous tree fruit farm	12	6
Manufacturing (20–39)	44	23
Poultry slaughtering	23	12
Corrugated and solid fiber boxes	10	5
Pesticide formulation	8	4
Services (70–89)	13	7
Wholesale trade (50–51)	11	5
Other	14	8
Agent[a]		
Organophosphate	71	36
Sulfur	36	18
Chlorine, hypochlorites	33	17
Pyrethrins	9	5
Propargite	9	5
N-methyl carbamates	7	4
Organochlorines	5	3
Other	27	14
Functional use category[a]		
Insecticide	97	49
Antimicrobial disinfectant	34	17
Fungicide	34	17
Miticide	10	5
Herbicide	5	3
Other	19	9

Note. Twenty-seven cases classified as unlikely were excluded; analyses excluding uncertain cases produced similar results. Missing data were excluded in the calculation of percentages.
[a]More than one pesticide in some case reports.

pesticide illness, was conducted in spring 1988 to identify potential health care providers for case reporting and to obtain a measure of potential underreporting. One hundred sixty-nine respondents reported treating 342 work-related pesticide illnesses in 1987 (the year before the SENSOR project began), as compared with 308 illnesses reported in the same year by the existing reporting system.[8] Health care providers from 10 medical facilities (3 occupational health practices, 3 emergency rooms, and 4 rural community health centers) were selected from survey respondents and other sources based on urban/rural distribution and diversity of practice setting. The 102 providers and their clerical staffs were recruited in face-to-face meetings starting in mid-1988. Reporters were given a manual covering reporting requirements, reporting guidelines, report forms, and educational materials.[11–13] The guidelines directed providers to report suspected or confirmed pesticide illness in four specific categories (systemic intoxication due to cholinesterase inhibitors, other systemic intoxications, dermatologic conditions, pesticide chemical eye injuries) and one general category (for any other illnesses or medical conditions related to pesticide exposure).

A protocol (Figure 1) was developed for receiving case reports and for sequencing and prioritizing follow-up activities based on probable pesticide relatedness, severity and clustering of cases, and suitability of agricultural cases for preventive interventions. Only a subset of prioritized case patients was then followed up, first with a 50-minute telephone or face-to-face standardized interview and then, conditioned on patient approval, by telephone contact with the employer for a 30-minute structured interview. Agricultural pest control companies and farms were prioritized for an on-site visit. Employer permission was requested, and a site visit was scheduled. In 1991, to increase the number of reports for worksite visits, cases of 16 providers reporting agricultural cases from Fresno and two neighboring counties were included; however, these providers did not receive reporting guidelines, report forms, or educational materials from the SENSOR project.

Cases were confirmed into the categories of definite, probable, possible, uncertain, and not pesticide related based on standardized criteria factoring signs, symptoms, and laboratory findings; involvement of case patients and of witnesses to the exposure incident; temporal sequence of exposure and illness; biological plausibility; and epidemic clustering. Industry,[14] pesticide functional use category, and

TABLE 2—Characteristics of 81 Interviewed Case Patients Reported by California SENSOR Providers, 1988 through 1991

	Agricultural Workers[a]		Nonagricultural Workers	
	No.	%	No.	%
Educational attainment				
Grade school	34	67	1	4
Some high school	10	20	2	8
High school graduate	7	13	21	88
Coworkers not seeking medical treatment	14	42	6	40
Medical bills paid by workers' compensation	30	61	15	65
Field sanitation provided				
Toilet	32	64	16	89
Hand-washing facilities	35	71	18	86
Drinking water	30	60	21	100
Showers	11	21	9	60
Change clothes after work	10	20	7	50
No training	27	56	13	65
Shown/read pesticide label	20	53	4	36

Note. Eight cases classified as unlikely were excluded. Missing data were excluded in the calculation of percentages.
[a]31 field workers and 22 workers who mixed, loaded, and/or applied pesticides as employees of farms or pest control companies.

TABLE 3—Field Investigations at Index Case Work Sites in California SENSOR Surveillance System, 1988 through 1991

Type of Work Site	No.	Activity at Exposure	Pesticides
Farm[a]	8	Application	Methomyl, diazinon, glyphosate
		Drift	Azinphos-methyl, propargite
		Field work	Cryolite
		Equipment maintenance	Methidithion
Pest control service[b]	3	Mixing, loading, application	Azinphos-methyl, mevinphos, naled, profenphos, endosulfan
Packing shed[c]	2	Sorting	Chlorine
		Fumigation	Sulfur dioxide
Formulation	1	Cleanup	Dimethoate
		Bagging	Carbofuran
School	1	Application	Glyphosate, surflan

[a]Citrus, grape, stone fruit, walnut, or vegetable.
[b]Two aerial services and one ground application service.
[c]Citrus and grapes.

chemical class were categorized by means of standard references.[15,16]

Field Investigations

On-site, nonenforcement field investigations involved a walk-through of operations and confidential interviews with employers and workers to evaluate engineering controls, equipment maintenance, training, medical monitoring, work practices, administrative practices, hazard communication, and personal protective equipment. Field investigations took place independently of or after enforcement inspections (in the latter, SENSOR staff observed but did not participate). On-site inspections were followed up with 7- to 10-page reports including recommendations. These reports were compared with those generated by enforcement agencies by searching the text of respective reports for matching recommendations.

As a means of broadening this traditional health hazard evaluation model, university-based pest management professionals were brought to selected work sites to identify the reasons for use of a pesticide and to offer growers alternative strategies to minimize future pesticide use based on integrated pest management principles.[17]

Temporal Changes in Case Reporting

Changes in provider reporting were quantitatively evaluated with data from the preexisting reporting system, which contained computerized abstracts from both Pesticide Illness Reports and Doctors' First Reports. SENSOR providers were matched by name and/or institution and compared with non-SENSOR providers in the same county from 1986 through 1990, the last year of available data. Secondary clusters with five or more case reports were excluded from analysis for both SENSOR and non-SENSOR providers to eliminate distortions in reporting due to large epidemic clusters.

Results

Forty-five of 102 providers reported 230 cases from October 1988 through December 1991. Of these, 217 cases from 80 work sites met reporting guidelines for suspected work-related cases. One hundred forty-two (66%) were confirmed as definite, probable, or possible; 48 (21%) were classified as uncertain because of missing information; and 27 (13%) were categorized as unlikely to be pesticide related (most of these were work-related exposures to fertilizers or other agricultural chemicals). Three occupational health practices reported 94 cases (49%, excluding those classified as unlikely), and three emergency rooms reported 37 cases (20%).

Of 118 case patients selected for follow-up, 89 (77%) completed interviews, 5 refused, and 24 (21%) were lost to follow-up (Figure 1). The employers of 40 case patients were selected for additional follow-up; 36 of these employers (90%) completed interviews and 4 refused. Of 21 work sites selected for field investigations, 15 were visited; 6 (29%) employers refused.

Case Reports

Case patients were, on average, 35 years old (SD = 11; range = 18 to 61). Most (75%) were male, and Spanish surnamed. Nearly half spoke Spanish at home, and half were agricultural workers (Table 1). Cholinesterase-inhibiting organophosphates or carbamates were identified in 40% of case reports, and contact irritants such as sulfur and propargite were identified in approximately 25%. Insecticides constituted nearly half of all identified agents; antimicrobial disinfectants and fungicides each constituted 17%. There were no fatalities, but four case patients were hospitalized for 7 days. There were three large epidemic clusters involving (1) 10 workers exposed to pyrolysis products of pesticides during a fire at a pesticide formulation plant; (2) 23 poultry processing workers exposed to chlorine gas; and (3) 15 office products workers exposed to a pyrethrin-containing insecticide after a structural pest control treatment.

Among case patients selected for follow-up interviews, educational attainment was lowest among agricultural workers, only 13% of whom had completed high school (Table 2). Illnesses were characterized by symptoms of headache and dizziness (72%), nausea (59%), skin rash (64%), and eye irritation (73%). Fifty-one percent lost no workdays or 1 workday due to their illness, and 36% lost between 4 and 16 days. Eleven workers (14%) reported being required to work while ill, lacking prompt medical care, or being required to pay for medical treatment. Forty-two percent of interviewed index case patients, including seven with symptomatic coworkers, reported that coworkers present during the same exposure episode did not seek medical treatment.

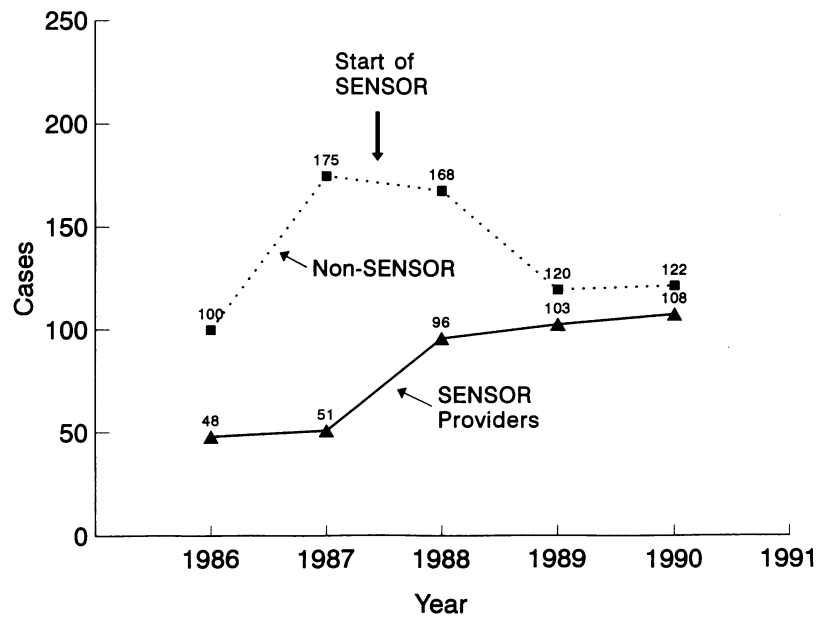
A majority of workers, both agricultural (56%) and nonagricultural (65%), reported not receiving any training in pesticide hazards from their employer. Among agricultural case patients, 70% of mixer-loader-applicators and 33% of field workers recalled having read or seen the label of the pesticide they were exposed to or were working with, and roughly a third reported a lack of toilets at the work site. Eight of 53 agricultural workers (15%) reported urinating or defecating in the fields. The proportions reporting a lack of hand-washing facilities (29%), drinking water (40%), and showering facilities (79%) were greater among agricultural workers. Only 20% of agricultural workers changed out of their work clothes at the end of their shift.

While all nonagricultural workers and all mixer-loader-applicators were aware of the existence of workers' compensation before their illness, nearly 40% of all workers reported that workers' compensation was not the expected source of

TABLE 4—Comparison of Recommendations of SENSOR and Agricultural Enforcement Agencies at Work Sites Visited by SENSOR, 1988 through 1991

	SENSOR		Agricultural Enforcement Agency, No.
	No.	%	
Administrative practices[a]	24	21	0
Medical monitoring[b]	16	14	2
Respirator use	15	13	0
Other personal protective equipment[c]	15	13	2
Training	10	9	1
Equipment maintenance	3	2	0
Engineering controls[d]	3	2	1
Posting of warnings before reentry	3	2	0
Pesticide use reduction[e]	20	17	. . .
Other[f]	8	7	1
Total	117	100	7

Note. The agricultural enforcement agency issued two citations for violations of the agricultural safety code and made one recommendation not made by SENSOR.
[a]Includes supervision, record keeping, and other organizational responsibilities.
[b]Includes ongoing medical evaluation and tracking of blood cholinesterase activity.
[c]Includes eye protection, gloves, clothing, boots, and so forth.
[d]Includes closed systems for mixing and loading pesticides.
[e]Includes recommendations from integrated pest management consultant.
[f]Includes industrial hygiene monitoring, access to showers, and personal hygiene.



Note. During 1988 through 1990, 243 providers reported pesticide illness cases in Fresno County; 68 of the case patients were employed at facilities recruited into the SENSOR project (SENSOR providers).

FIGURE 2—Reporting of pesticide illness by SENSOR and non-SENSOR providers as detected by the existing mandatory reporting system, 1986 through 1990.

payment for medical bills. Among the field workers, 20% were not aware of the existence of workers' compensation, and only 47% reported it as the source of payment of their medical bills for the pesticide illness.

Field Investigations

Field investigations were carried out at eight farms, three pest control companies, two packing sheds, one pesticide formulation facility, and one school yard (Table 3), mostly involving exposure to organophosphates and carbamates. At nearly every work site, SENSOR staff identified inadequate safety training, nonexistent or inadequate medical monitoring, lax supervision, inadequate personal protective equipment, engineering flaws in aerial application equipment, improper respirator use, and they also reported an almost universal lack of respirator fit testing.

In total, 117 specific recommendations were made to employers that reflected routine and serious inadequacies (Table 4). Of these, only 7 were identified in reports of agricultural enforcement agencies, which cited two employers for violations of the agricultural safety code and made one recommendation not made by SENSOR.

Temporal Changes in Case Reporting

The number of reports of SENSOR providers doubled between 1987 and 1988 and plateaued during 1989 and 1990 (Figure 2), mostly as a result of increased reporting among two of the three occupational health practices and one of the two hospital emergency rooms. The number of reports of non-SENSOR providers peaked in 1987, decreased slightly in 1988, and then fell to levels above the 1986 baseline for 1989 and 1990. During 1989 and 1990, SENSOR and non-SENSOR case patients differed little by age (same mean age of 35 years), gender (80% vs 89% male), or agricultural employment (48% vs 40%).

Discussion

An active surveillance system linked to work-site follow-up was associated with modestly increased provider reporting and revealed a clustering of risk factors for pesticide illness among index cases that was verified by direct observation at selected work sites but went largely undetected by enforcement agencies. Most illnesses were of mild to moderate severity and involved up to 1 lost workday.

Limitations

Before a discussion of these findings, several limitations need to be acknowledged. The surveillance methodology was not intended to be population based, so total counts or rates of pesticide illness cannot be inferred. Only one county was the focus of surveillance activities. However, Fresno County is among the most advanced in California in terms of pesticide illness prevention activities. It has a large agricultural enforcement program with personnel trained in standardized data collection and an automated system to track pesticide use. This suggests that our findings may be understated when applied elsewhere.

High-risk work sites were identified, but it is not known whether the prevalence of risk factors for pesticide illness differed between work sites where cases were reported and those where cases were not reported. Future studies could resolve this by sampling work sites without case reports to determine the prevalence of risk factors and so define and validate the positive predictive value of such a report.

Case Reports

Approximately 40% of case patients indicated that coworkers involved in the same exposure incident did not seek medical treatment. Workers were extremely reluctant to provide their coworkers' names, limiting our ability to verify this finding. Nonetheless, questionnaire responses suggest the convergence of several barriers to complete case ascertainment. Although interviewed workers reported knowing about workers' compensation, a significant percentage, especially among field workers, did not indicate workers' compensation as the expected source of payment for medical bills. A significant percentage of workers (12.5% of the 89 interviewed) also alleged incidents of employment discrimination because of their illness, and some of the allegations directly involved responsibility for payment of medical bills. Under these circumstances, low-income workers, especially those involved only with seasonal work and those with limited English language skills, would not be expected to jeopardize their jobs for the treatment of any but the most serious illness.

Direct observation of work sites corroborated the inadequacy of many training programs. The state of training probably reflects, in part, the lack of legally required training for field workers that prevailed until July 1992, when the California Environmental Protection Agency implemented a hazard communication standard similar to that of the Occupational Safety and Health Administration. However, what constitutes effective training needs to be seriously addressed in populations of low-literacy, non-English-speaking workers handling toxic materials.[18]

Field sanitation and access to the tools of personal hygiene, which can play an important role in decontamination of pesticide residues, were reportedly lacking at a significant percentage of agricultural work sites.

Field Investigations

A large percentage (76%) of employers voluntarily participated in work-site investigations. Access to work sites was probably facilitated by the extensive community liaison, and there were several anecdotes of growers consulting with agricultural officials prior to participating in SENSOR field investigations. Moreover, growers were cognizant that enforcement personnel investigate every reported pesticide illness.

Deficiencies were observed at nearly every work site, yet only a very low percentage of recommendations to counter these deficiencies were identified by agricultural enforcement personnel. Some of the recommendations made by SENSOR were related to regulations of the state Occupational Health and Safety Administration (16%) or were related to pesticide use reduction through integrated pest management (17%), areas outside the scope of enforcement of agricultural pesticide use. Although they receive training related to enforcement, these agricultural enforcement personnel are not trained health and safety specialists. Moreover, none worked full time on pesticide health and safety, none were fluent in Spanish, and crop production activities often took priority over all but the most urgent pesticide illness investigations. Although identifying potential hazards is a crucial first step, long-term follow-up to determine whether recommendations were actually adopted went beyond available resources.

Several of the hazards involved exposure to highly toxic organophosphates in which medical monitoring by non-SENSOR providers was inattentive to seriously depressed cholinesterase activity and to the thresholds for medical removal and return to work[19] (as has been shown in previous studies[20]). For mixer-loader-

applicators and other workers requiring respiratory protection, the lack of respirator fit testing and selection of equipment was a common problem. Field investigations of aerial drift of pesticides revealed that pesticide applicators are sometimes unaware of the presence of workers in neighboring fields or do not provide sufficient notice of pesticide applications.

SENSOR demonstrated the feasibility of bringing integrated pest management professionals to work sites where pesticide illnesses had been reported. An important element was that of distancing the association between participation in SENSOR and enforcement activities. Employers were receptive to the process and to suggestions of how to reduce pesticide use.

Temporal Changes in Reporting

Providers participated and appeared to have responded by increased reporting. However, the maintenance of reporting through feedback to providers and community liaison was a labor-intensive process that led to only modest increases in reporting. Preexisting reporting laws that carried a civil penalty for not reporting and adherence to confidentiality of medical records were probably incentives for reporting.

Conclusions

The existing system of surveillance and follow-up in California, based largely on regulation and enforcement, underreports the magnitude of occupational pesticide but appears to have played an important role in reducing serious, acute work-related pesticide illnesses, from more than 131 hospitalized patients in 1971 to generally less than 50 per year since 1984.[7,8,21] Little further reduction was evident in the 1980s, suggesting that the current level of effort is associated with an endemic annual incidence of 1000 to 1500 physician-reported occupational pesticide illnesses. Further reduction will probably require a change in follow-up by enforcement agencies and/or changes in pest management practices. A model of enforcement based on that of the Occupational Safety and Health Administration, deploying trained health and safety professionals with undivided attention and orientation to protect worker health and safety, is likely to be more effective than the current agricultural enforcement model. Such a model also has the advantage of consolidating both pesticide and nonpesticide health and safety activities. Expansion of integrated pest management practices that are sensitive to worker health and safety—including chronic as well as acute health effects—is an avenue for further pesticide illness prevention. □

Acknowledgments

This study was presented at the 120th Annual Meeting of the American Public Health Association, November 1992, Washington, DC.

We wish to acknowledge the participating health care providers, workers, and employers without whom this project would not have been possible. Financial support and technical assistance were provided through a cooperative agreement with the National Institute for Occupational Safety and Health, and consultation in project evaluation was provided by the Public Health Practice Program Office, Centers for Disease Control and Prevention. Feedback and technical support were provided by staff of the Fresno, Madera, and Tulare county health departments; the Fresno County Department of Agriculture; the Fresno County Farm Bureau; California Rural Legal Assistance; the Madera-Fresno Medical Society; California State University (Fresno); the University of California statewide integrated pest management programs and Kearney Field Station; the University of California Cooperative Extension Agricultural Labor Management Program; the Worker Health and Safety Branch, California Environmental Protection Agency; and Marion Moses, MD. Administrative support was provided by the California Public Health Foundation. We thank Lupe Ortiz, Kate Cummings, Jim Bellows, Barbara Materna, Arleen Ervin, Elizabeth Abello, and Susan Payne for their valuable assistance in data collection and analysis.Announcement

As part of the NIOSH-sponsored SENSOR project described in this article, the California Department of Health Services made a 23-minute video depicting five growers' experiences in adopting integrated pest management for their farms. "Protecting Crops, Protecting People: Can IPM Work For You?" is available free of charge from CDHS/Occupational Health Branch, 2151 Berkeley Way, Annex 11, Berkeley, CA 94704.

References

1. *Hearing before a Subcommittee of the Committee on Governmental Operations,* 98th Cong, 2nd Sess (1984) (testimony of D. Millar on the OSHA injury and illness information system).
2. Baker EL. Sentinel Event Notification System for Occupational Risks (SENSOR): the concept. *Am J Public Health.* 1989; 79(suppl):18–20.
3. Istre GR. Disease surveillance at the state and local levels. In: Halperin W, Baker EL, Monson RR, eds. *Public Health Surveillance.* New York, NY: Van Nostrand Reinhold; 1992:42–55.
4. Rutstein DD, Mullan RJ, Frazier TM, Halperin WE, Melius JM, Sestito JP. Sentinel events (occupational) for physician recognition and public health surveillance. *Am J Public Health.* 1983;73:1054–1062.
5. Cal Code of Regulations, Title 3 (1993).
6. Kahn E. Pesticide illness in California. *J Occup Med.* 1976;18:693–696.
7. Maddy KT, Edmiston S, Richmond D. Illness, injury, and deaths from pesticide exposures in California, 1949–1988. *Rev Environ Contam Toxicol.* 1990;114:57–123.
8. Mehler L. *Summary of Illness and Injuries Reported by Physicians as Potentially Related to Pesticides, 1989.* Sacramento, Calif: California Department of Pesticide Regulation; 1991.
9. Maizlish NA, Rudolph LA, Dervin KA, Sankaranarayan M. Surveillance and prevention of work-related carpal tunnel syndrome: an application of the Sentinel Event Notification System for Occupational Risks (SENSOR). *Am J Ind Med.* 1995;27:715–729.
10. Insalaco C. *Annual Crop and Livestock Report, 1989.* Fresno, Calif: Fresno County Department of Agriculture; 1989.
11. Mitling J, Barnett P, Coye MJ, O'Malley M, Clements C. Clinical management of field worker organophosphate poisoning. *West J Med.* 1985;142:514–521.
12. Maddy K, Ames RG, Knaak JB, et al. Outbreak of severe dermatitis among orange pickers—California. *MMWR.* 1986;35: 465–467.
13. Morgan DP. *Recognition and Management of Pesticide Poisonings.* 4th ed. Washington, DC: Environmental Protection Agency; 1989.
14. *Standard Industrial Classification Codes.* Washington, DC: Office of Management and Budget; 1989.
15. *Farm Chemicals Handbook, 1991.* Willoughby, Ohio: Meister Publishing; 1991.
16. Hayes WJ. *Pesticides Studied in Man.* New York, NY: Williams & Wilkins; 1982.
17. Flint ML, van den Bosch R. *Introduction to Integrated Pest Management.* New York, NY: Plenum Press; 1981.
18. Weinger M, Lyons M. Problem-solving in the fields: an action oriented approach to farmworker education about pesticides. *Am J Ind Med.* 1992;22:677–690.
19. *Medical Supervision of Pesticide Workers. Guidelines for Physicians.* Berkeley, Calif: California Department of Health Services; 1988.
20. Ames RG, Mengle DC, Brown SK, Kahn E, Stratton JW, Jackson RJ. *Cholinesterase Activity Depression among California Pesticide Applicators: Results from the 1985 Cholinesterase Monitoring Program.* Berkeley, Calif: California Department of Health Services; 1987.
21. Peoples SA, Maddy KT, Smith CR. *An Overview of Occupational Exposures to Pesticides in California in 1981.* Sacramento, Calif: California Department of Food and Agriculture; 1982.